OBJECT

IMAGE CAPTURE
SECTION ╭1

RANGE IMAGE
(SAMPLE IMAGE)

RANGE IMAGE
(LATEST IMAGE)

IMAGE DEFORMATION
SECTION ╭2

DEFORMED
IMAGE

IMAGE COMPARISON
SECTION ╭3

RECOGNITION
RESULT

FIG. 1

LIGHT-EMITTING
UNIT
101

TIMING SIGNAL
GENERATION UNIT
104

REFLECTED LIGHT
EXTRACTION UNIT
102

LIGHT-RECEIVING
UNIT
103

IMAGE CAPTURE SECTION

1

FIG. 2

0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	255	0	0	0	0	0
0	0	250	0	0	0	0	0
0	0	250	0	0	0	0	0
0	220	250	0	220	0	0	0
0	220	220	0	220	0	0	0
0	220	220	200	200	0	0	0

FIG. 3
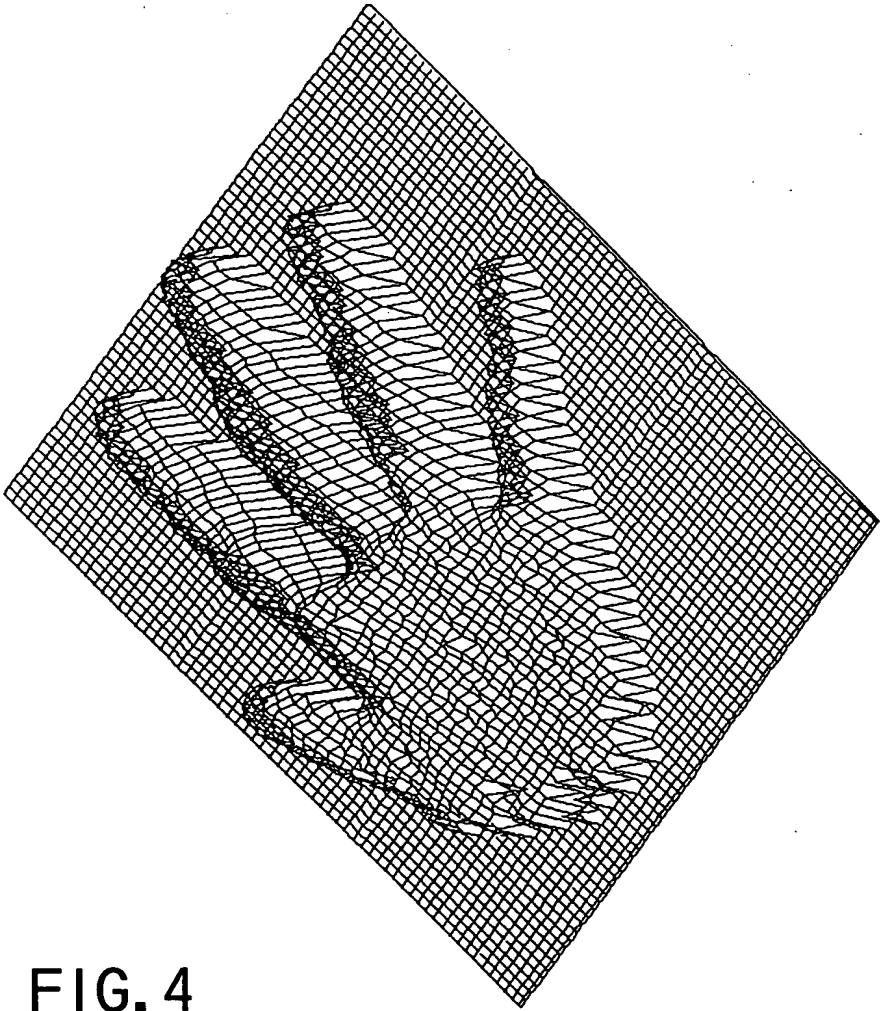
FIG. 4
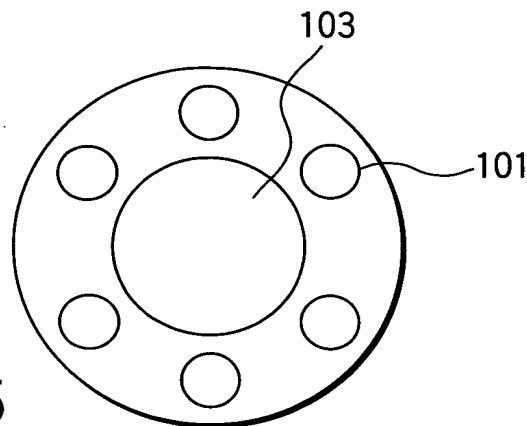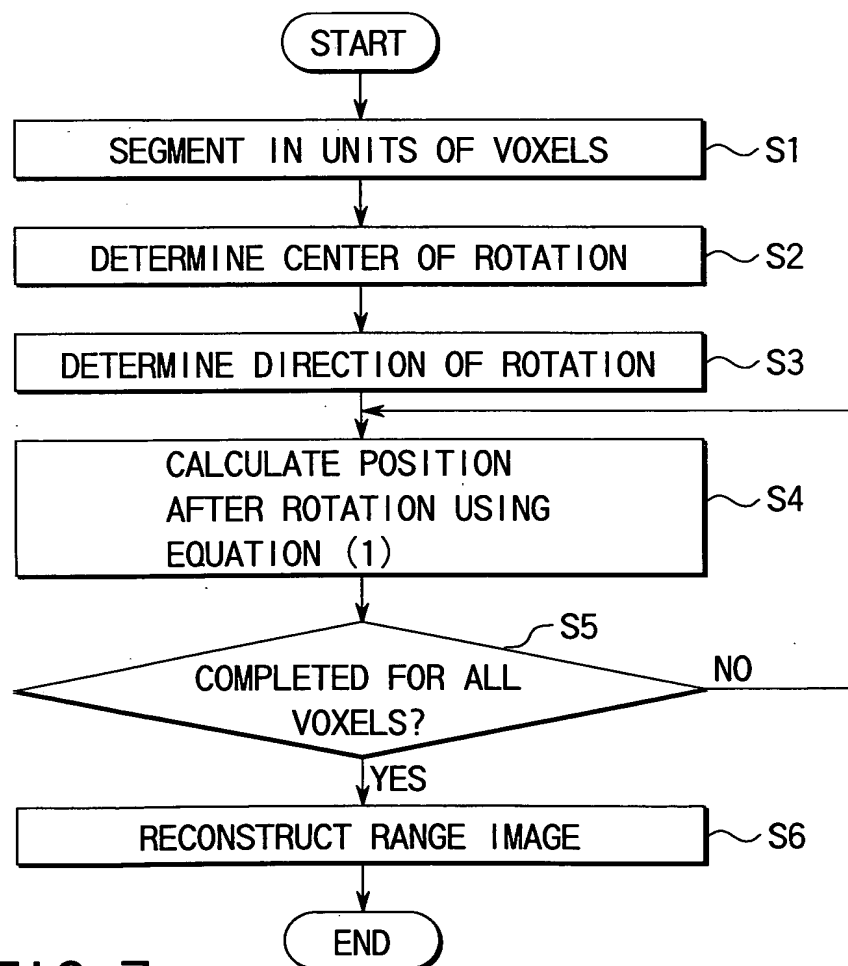
103

101

FIG. 5

```
        ┌─────────┐
        │  START  │
        └────┬────┘
             │
   ┌─────────▼──────────────────────┐
   │ SEGMENT IN UNITS OF VOXELS     │───S1
   └─────────┬──────────────────────┘
             │
   ┌─────────▼──────────────────────┐
   │ DETERMINE CENTER OF ROTATION   │───S2
   └─────────┬──────────────────────┘
             │
   ┌─────────▼──────────────────────┐
   │ DETERMINE DIRECTION OF ROTATION│───S3
   └─────────┬──────────────────────┘
             │
   ┌─────────▼──────────────────────┐
   │ CALCULATE POSITION             │
   │ AFTER ROTATION USING           │───S4
   │ EQUATION (1)                   │
   └─────────┬──────────────────────┘
             │
          ╱──▼──╲  S5
         ╱       ╲
    ◄───┤ COMPLETED FOR ALL ├──── NO
         ╲  VOXELS? ╱
          ╲──┬──╱
             │YES
   ┌─────────▼──────────────────────┐
   │ RECONSTRUCT RANGE IMAGE        │───S6
   └─────────┬──────────────────────┘
             │
        ┌────▼────┐
        │   END   │
        └─────────┘
```
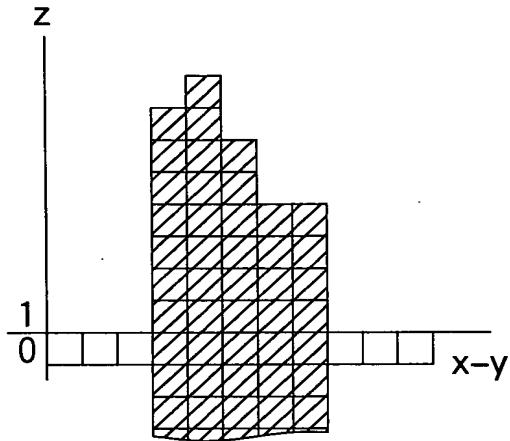
FIG. 7

Frame
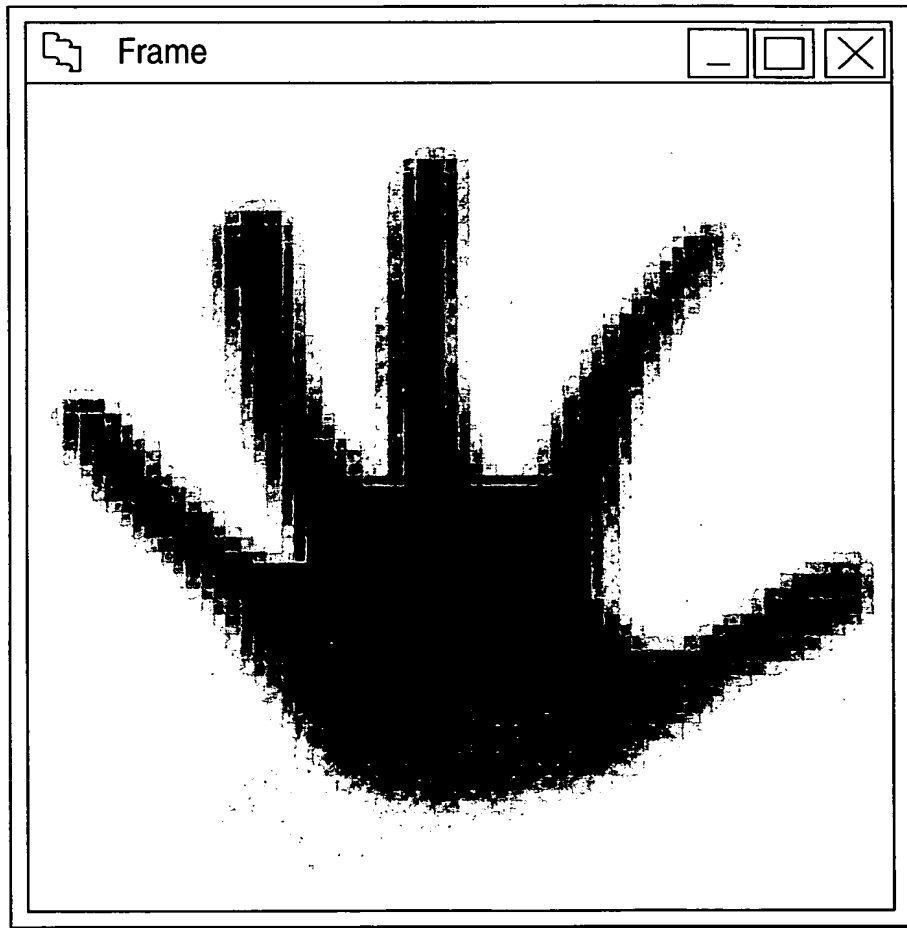
FIG.6
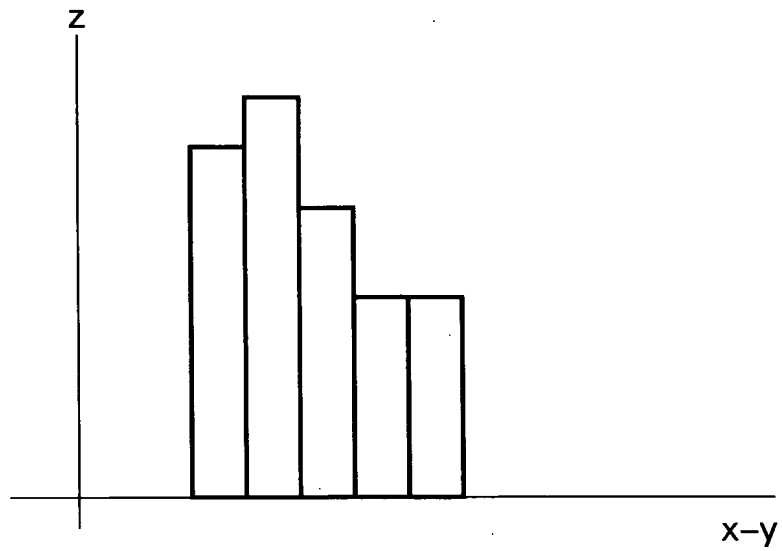
FIG. 8A

SEGMENT IN UNITS
OF VOXELS

VOXELS

(x, y)

FIG. 8B

FIG. 9A

FIG. 9B

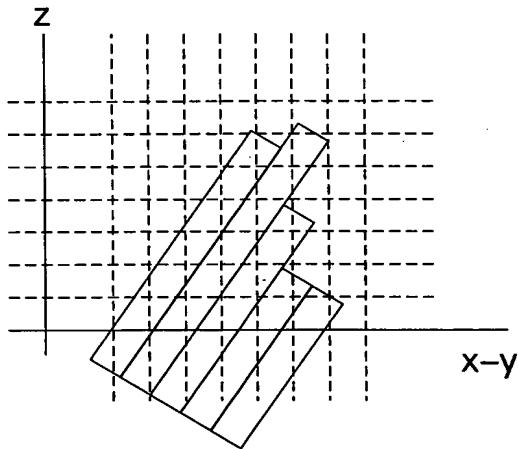FIG. 9C

FIG. 9D
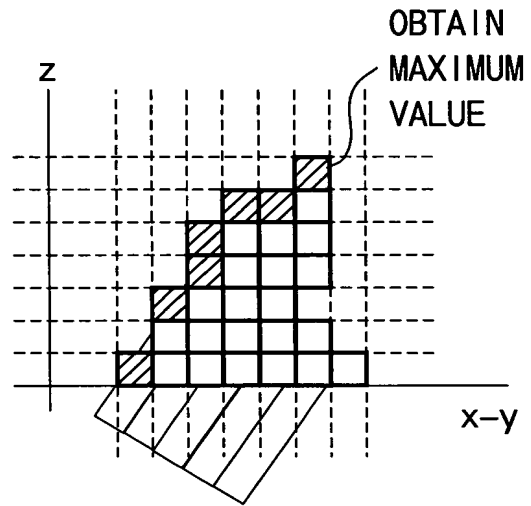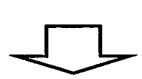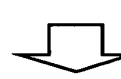
OBTAIN
MAXIMUM
VALUE

z

x–y

FIG. 10A

z

x–y
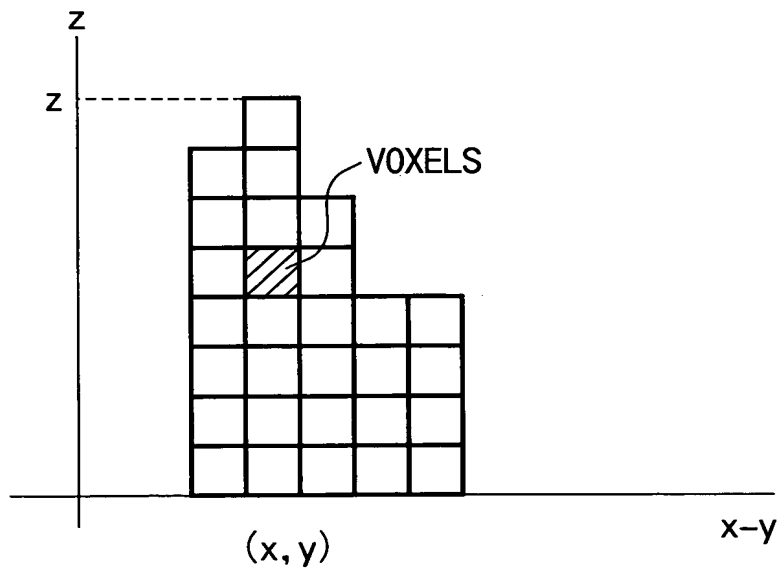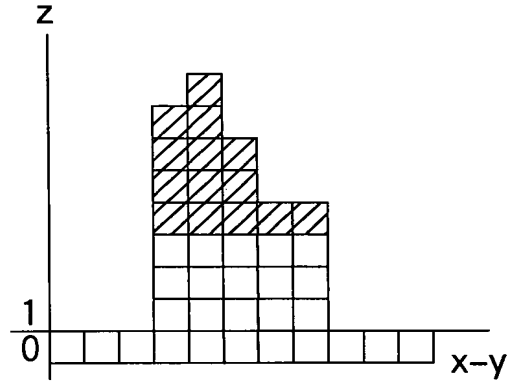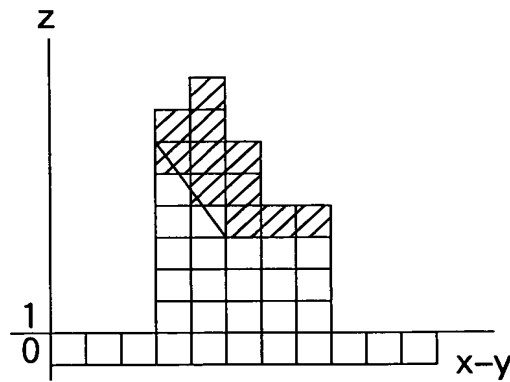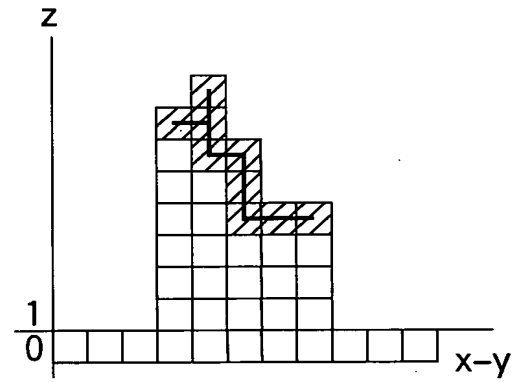
FIG. 11A

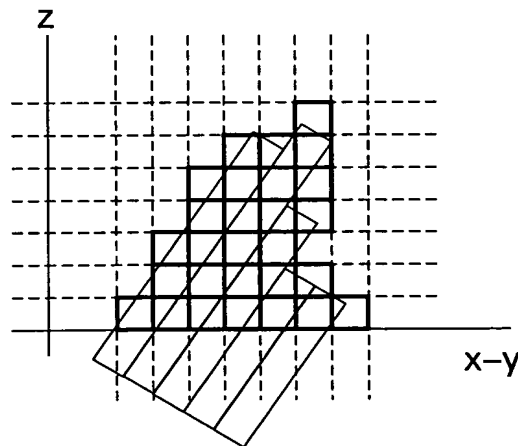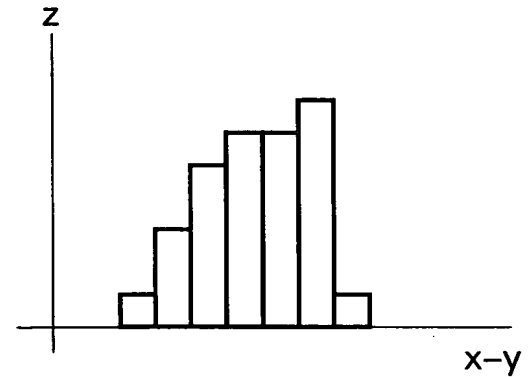COMPUTE (x', y', z')
USING EQUATION (1)
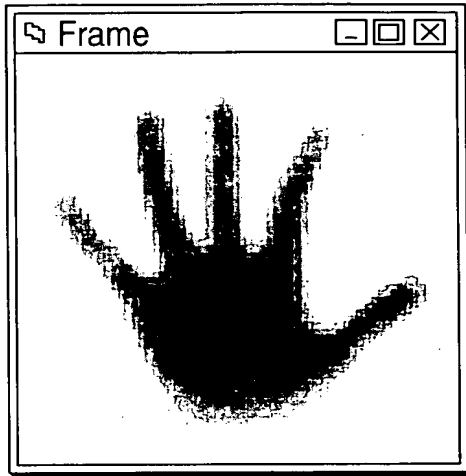
RECONSTRUCT
RANGE IMAGE
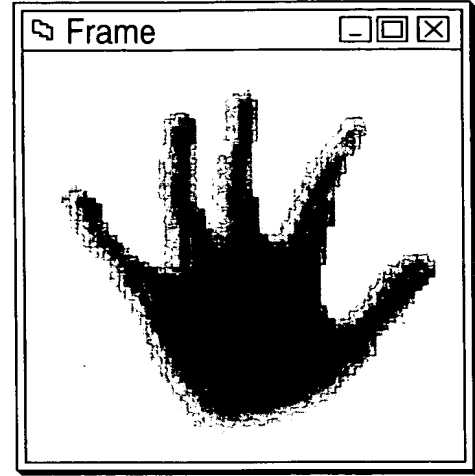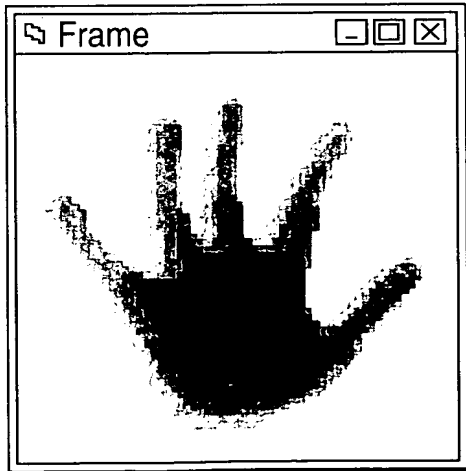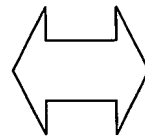
z

x–y

FIG. 10B

z

x–y

FIG. 11B

SAMPLE IMAGE

FIG. 12A

DEFORMED IMAGE

FIG. 12B

DEFORMED IMAGE

FIG. 13A

COMPARISON

LATEST IMAGE

FIG. 13B

```
                    ┌─────────────┐
                    │    START    │
                    └─────────────┘
                           │
                           ▼
        ┌──────────────────────────────┐
        │    NORMALIZE  POSITION        │── S11
        └──────────────────────────────┘
                           │
                           ▼
        ┌──────────────────────────────┐
        │    COMPUTE  HAMMING           │── S12
        │    DISTANCE  (H)              │
        └──────────────────────────────┘
                           │
                           ▼
                        S13
                    ╱─────────╲           NO
                 ╱───────────────╲ ──────────────┐
                 ╲   H<Th?        ╱               │
                    ╲─────────╱                   │
                        │ YES                     │
                        ▼  S14                     ▼  S15
        ┌────────────────────────┐  ┌────────────────────────┐
        │ DETERMINE  THAT  TWO   │  │ DETERMINE  THAT  TWO   │
        │ IMAGES  ARE  SIMILAR   │  │ IMAGES  ARE  NOT       │
        │ TO  EACH  OTHER        │  │ SIMILAR  TO  EACH OTHER│
        └────────────────────────┘  └────────────────────────┘
                        │                          │
                        ▼◄─────────────────────────┘
                    ┌─────────┐
                    │   END   │
                    └─────────┘
```
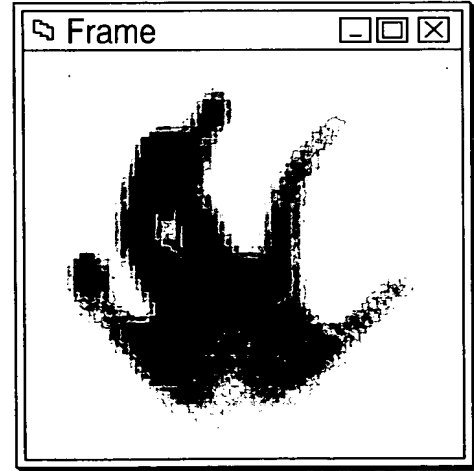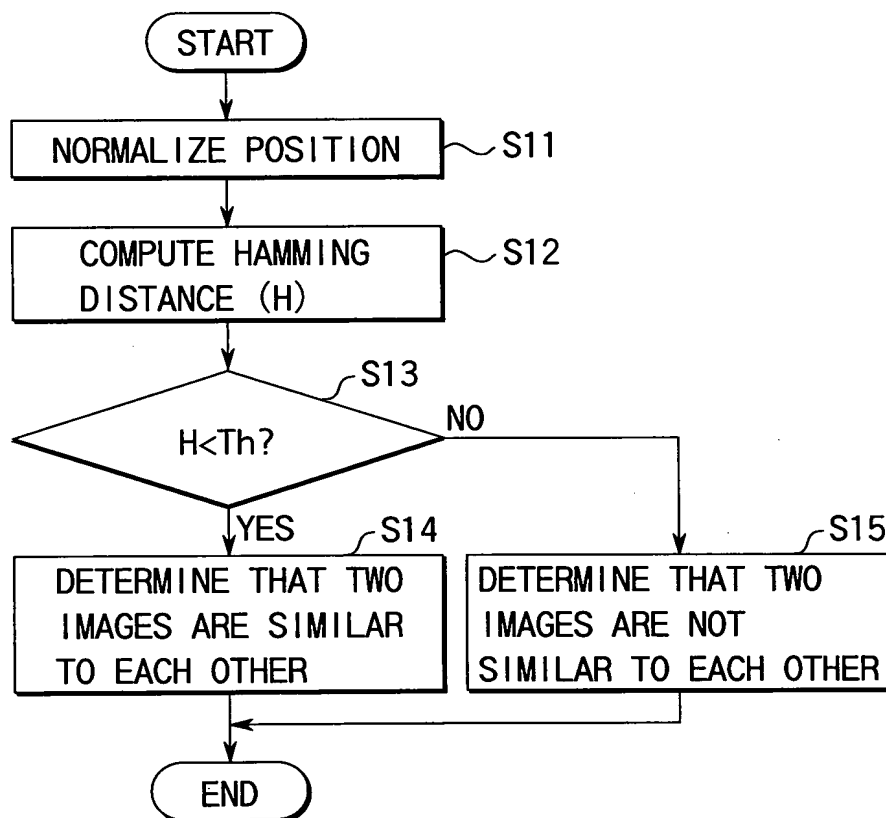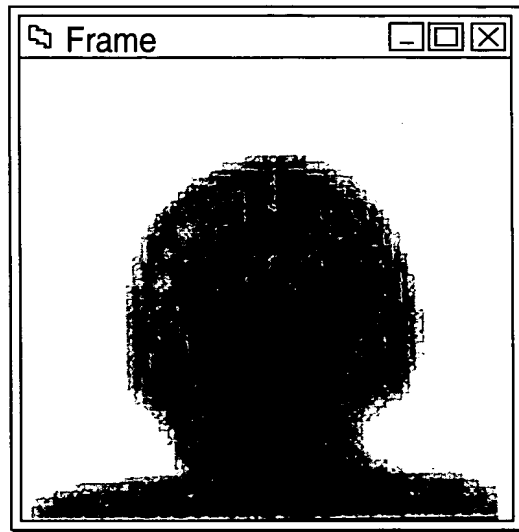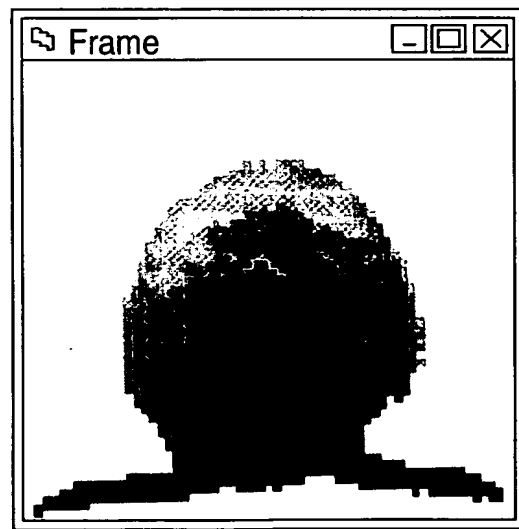
FIG. 14

SAMPLE IMAGE

FIG. 15

DEFORMED IMAGE

FIG. 16
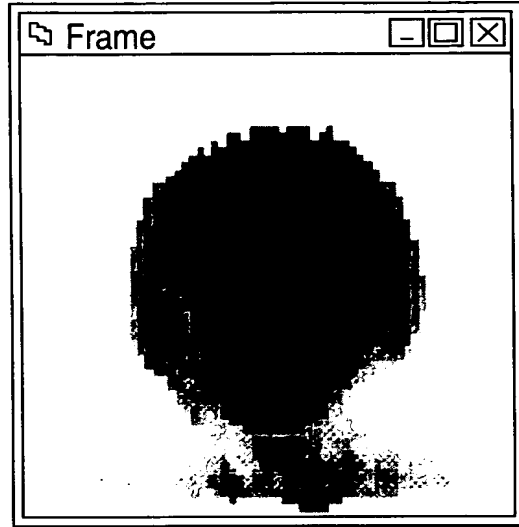
DEFORMED IMAGE

FIG. 17
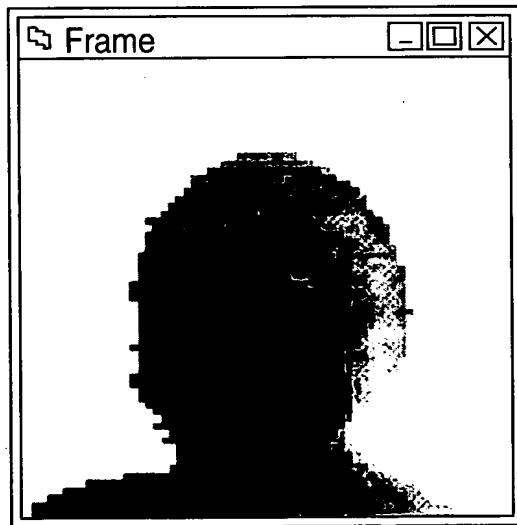
DEFORMED IMAGE

FIG. 18
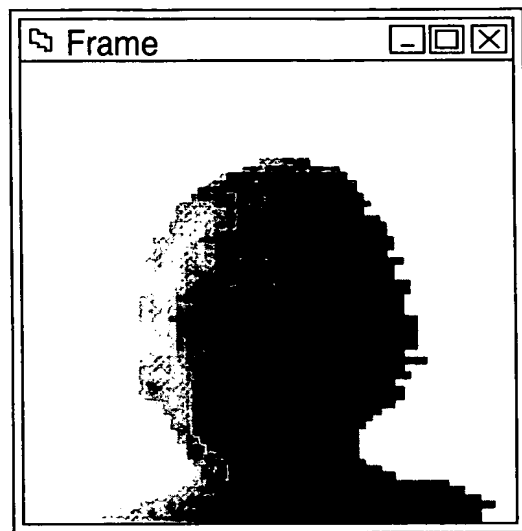
DEFORMED IMAGE

FIG.19

LATEST IMAGE

FIG.20

START

SELECT TEMPLATE IMAGE (Ti) — S21

NORMALIZE POSITION — S22

COMPUTE HAMMING DISTANCE (H) — S23

S24

COMPLETED FOR ALL TEMPLATE IMAGES? — NO

YES

SELECT TEMPLATE IMAGE (Tmin) WITH MINIMUM HAMMING DISTANCE (Hmin) — S25

S26

Hmin<Th? — NO

YES — S27

DETERMINE THAT LATEST IMAGE IS SIMILAR TO Tmin

S28

DETERMINE THAT NO SIMILAR IMAGE IS FOUND

END
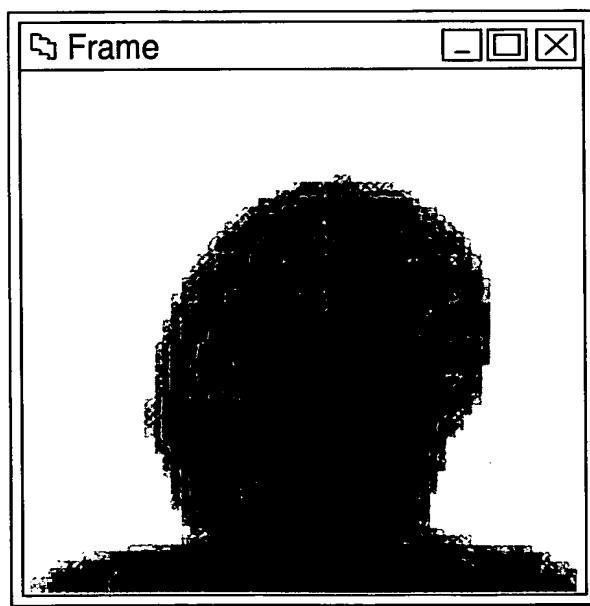
FIG. 21
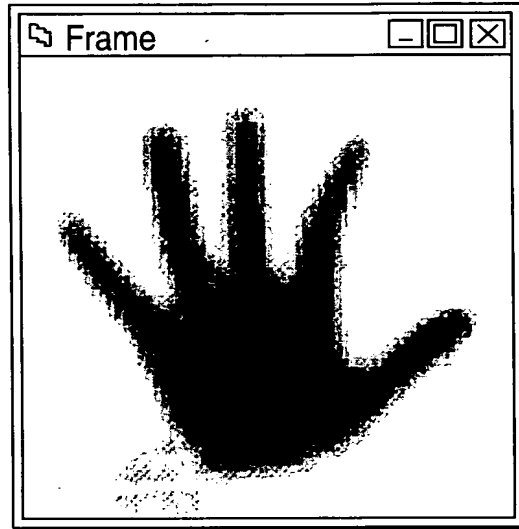
SAMPLE IMAGE

FIG. 22

DEFORMED IMAGE

FIG. 23

DEFORMED IMAGE

FIG. 24

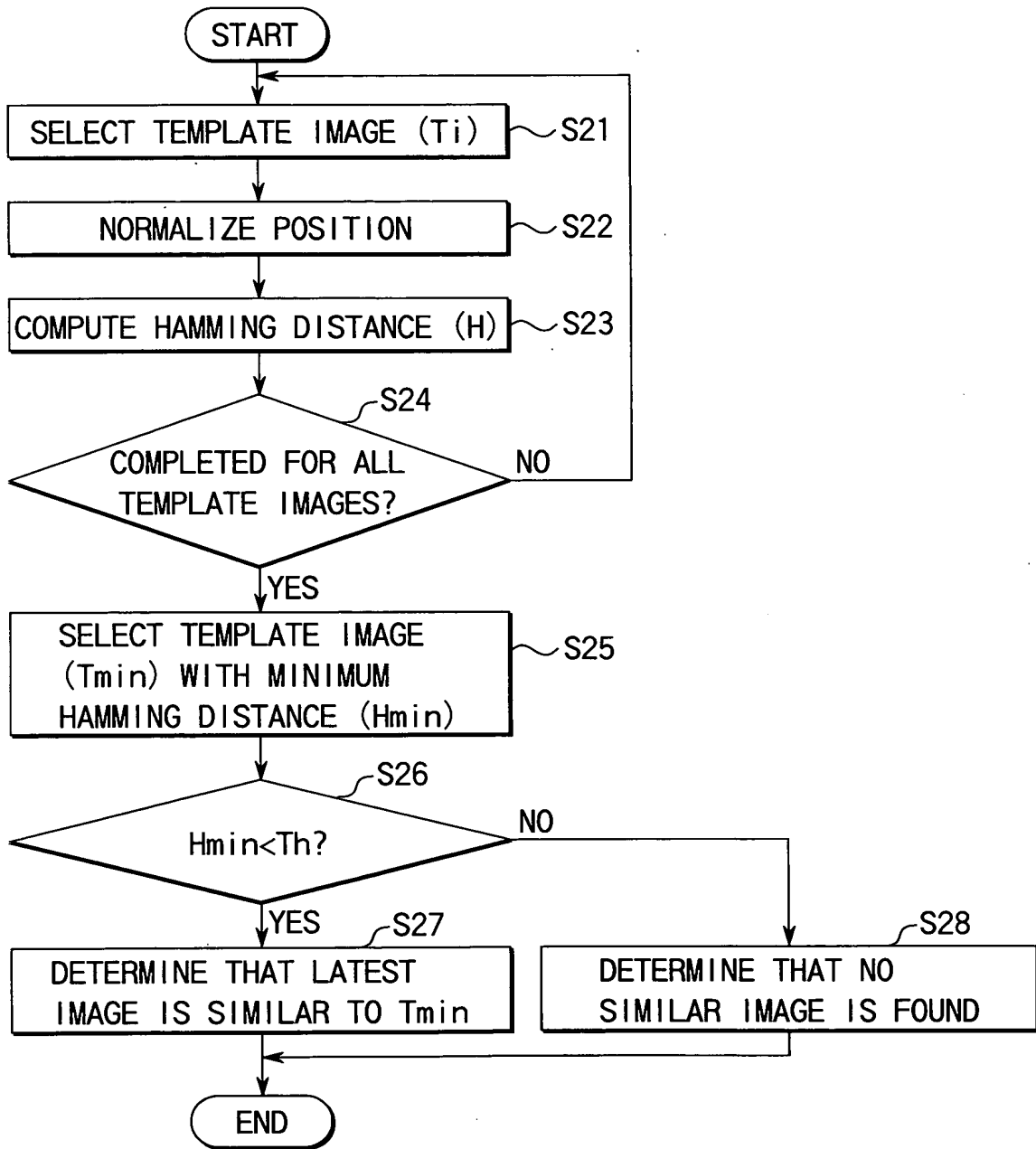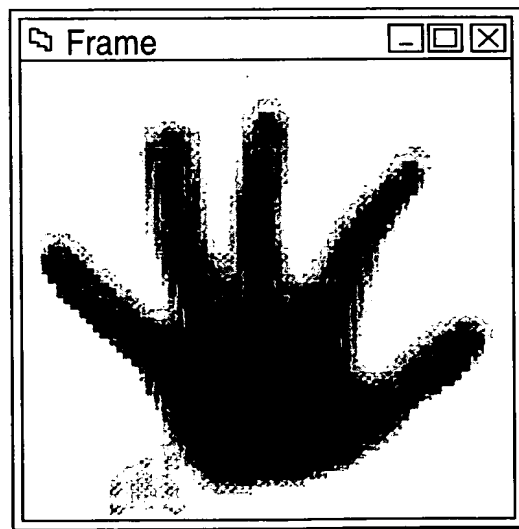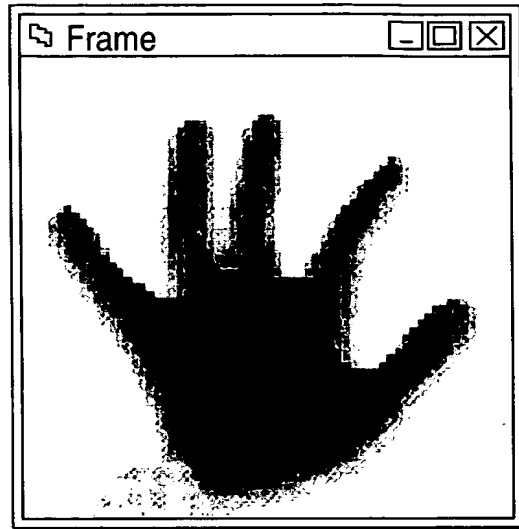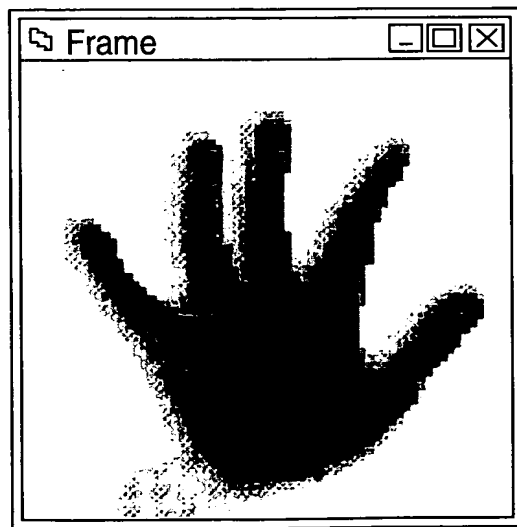DEFORMED IMAGE

FIG. 25
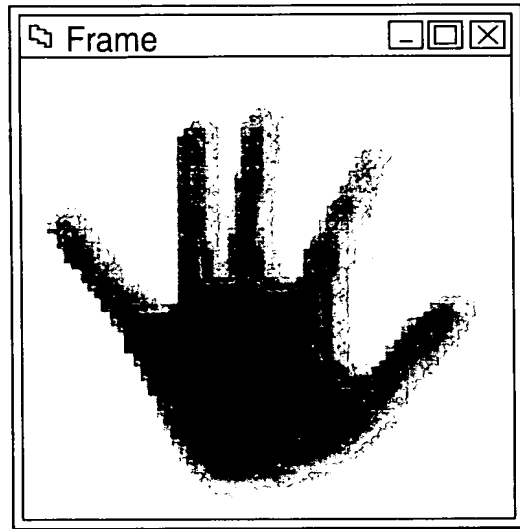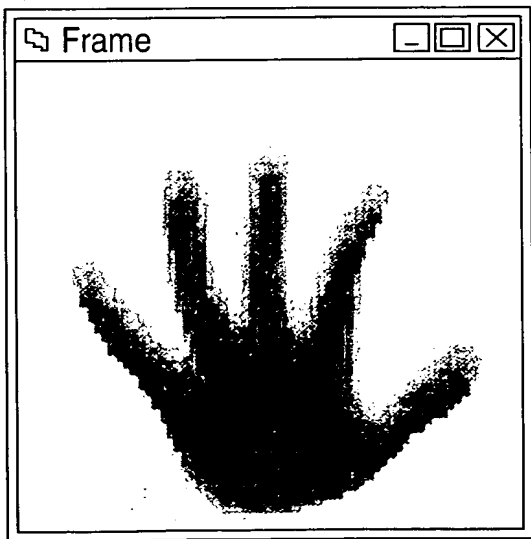
DEFORMED IMAGE

FIG.26

DEFORMED IMAGE

FIG.27A
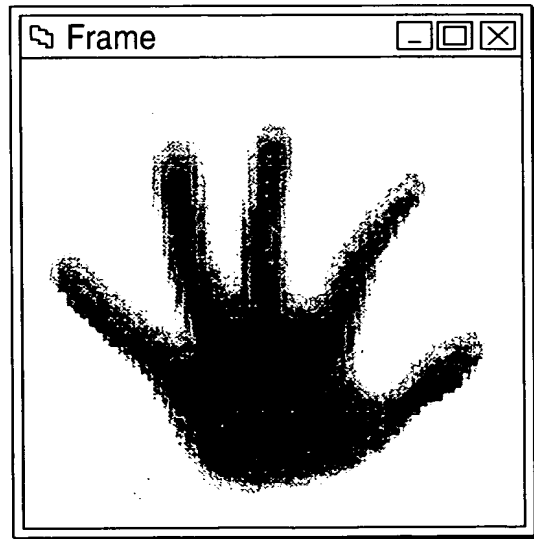
DEFORMED IMAGE

FIG.27B
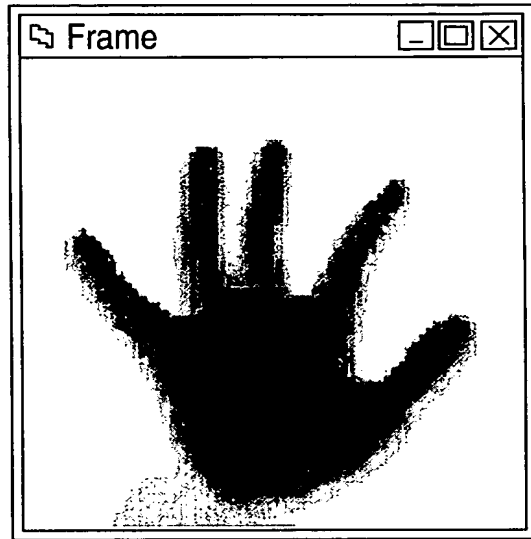
DEFORMED IMAGE

FIG. 28A

DEFORMED IMAGE

FIG. 28B

Frame
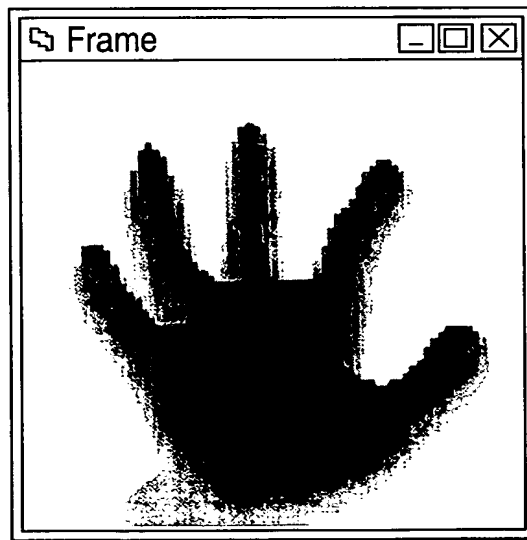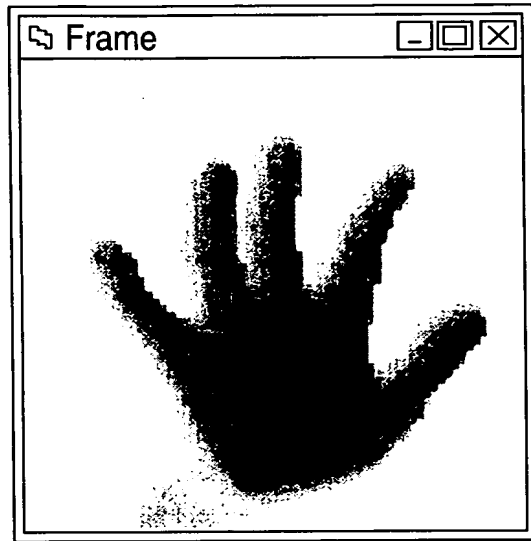
DEFORMED IMAGE

FIG. 29A

Frame
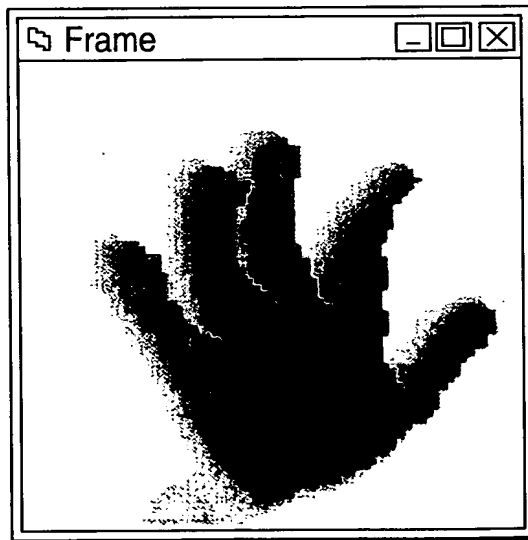
DEFORMED IMAGE

FIG. 29B
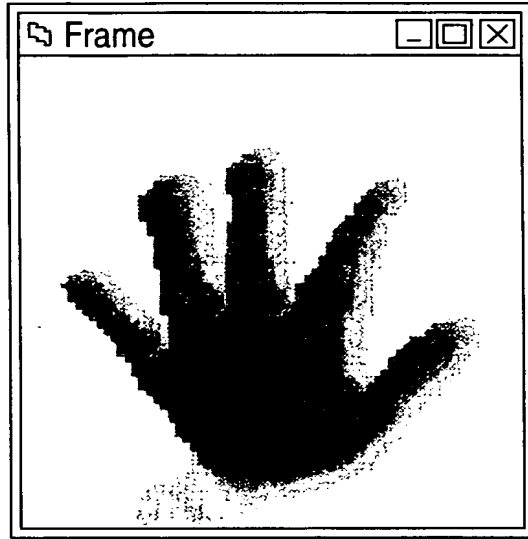
DEFORMED IMAGE

FIG. 30A

DEFORMED IMAGE

FIG. 30B

OBJECT

↓

```
┌─────────────────────┐ ⌐1
│  IMAGE CAPTURE      │
│  SECTION            │
└─────────────────────┘
```

RANGE IMAGE
(LATEST IMAGE)

RANGE IMAGE
(SAMPLE IMAGE)

↓

```
┌─────────────────────┐ ⌐2          ┌─────────────────────┐ ⌐3
│  IMAGE DEFORMATION  │   DEFORMED   │  IMAGE COMPARISON   │
│  SECTION            │──IMAGE──────→│  SECTION            │
└─────────────────────┘              └─────────────────────┘
                                              ↓
                                     ┌─────────────────────┐ ⌐4
                                     │  MOTION RECOGNITION │
                                     │  SECTION            │
                                     └─────────────────────┘
                                              ↓
                                     RECOGNITION
                                     RESULT
```

FIG. 31

OBJECT

↓

```
┌─────────────────────┐ ⌐1
│  IMAGE CAPTURE      │
│  SECTION            │
└─────────────────────┘
```

RANGE IMAGE
(LATEST IMAGE)

RANGE IMAGE
(SAMPLE IMAGE)

↓

```
┌─────────────────────┐ ⌐2          ┌─────────────────────┐ ⌐3
│  IMAGE DEFORMATION  │   DEFORMED   │  IMAGE COMPARISON   │
│  SECTION            │──IMAGE──────→│  SECTION            │
└─────────────────────┘              └─────────────────────┘
         ↑                                    ↓
┌─────────────────────┐ ⌐5          RECOGNITION
│  IMAGE DESIGNATION  │              RESULT
│  SECTION            │
└─────────────────────┘
         ↑
┌─────────────────────┐ ⌐6
│  IMAGE HOLDING      │
│  SECTION            │
└─────────────────────┘
         ↑
```

RANGE IMAGE
(RANGE IMAGE STREAM)
OBTAINED INSIDE
APPARATUS

RANGE IMAGE (RANGE IMAGE STREAM)
FROM EXTERNAL APPARATUS

FIG. 32

OBJECT

↓

IMAGE CAPTURE
SECTION ⌐1

RANGE IMAGE
(SAMPLE IMAGE)

RANGE IMAGE
(LATEST IMAGE)

IMAGE DEFORMATION
SECTION ⌐2

DEFORMED
IMAGE

IMAGE COMPARISON
SECTION ⌐3

MOTION PREDICTION
SECTION ⌐7

MOTION RECOGNITION
SECTION ⌐4

RECOGNITION
RESULT

FIG. 33

OBJECT

↓

IMAGE CAPTURE
SECTION ⌐1

RANGE IMAGE
(SAMPLE IMAGE)

RANGE IMAGE
(LATEST IMAGE)

IMAGE DEFORMATION
SECTION ⌐2

DEFORMED
IMAGE

IMAGE COMPARISON
SECTION ⌐3

FEATURE AMOUNT
EXTRACTION SECTION ⌐8

MOTION RECOGNITION
SECTION ⌐4

MOTION PREDICTION
SECTION ⌐7

RECOGNITION
RESULT

FIG. 34

OBJECT

↓

IMAGE CAPTURE SECTION　1

RANGE IMAGE
(SAMPLE IMAGE)

RANGE IMAGE
(LATEST IMAGE)

↓

IMAGE DEFORMATION SECTION　2 → DEFORMED IMAGE → IMAGE COMPARISON SECTION　3

↑

MOTION PREDICTION SECTION　7 ← MOTION RECOGNITION SECTION　4

↓

RECOGNITION RESULT

FIG. 35

OBJECT

↓

IMAGE CAPTURE SECTION　1

RANGE IMAGE
(SAMPLE IMAGE)

RANGE IMAGE
(LATEST IMAGE)

↓

IMAGE DEFORMATION SECTION　2 → DEFORMED IMAGE → IMAGE COMPARISON SECTION　3

RANGE IMAGE
(LATEST IMAGE)

↓

IMAGE COMPRESSION SECTION　9 ← MOTION RECOGNITION SECTION　4

↓

COMPRESSED IMAGE

FIG. 36

OBJECT

↓

IMAGE CAPTURE
SECTION ⌐1

RANGE IMAGE
(SAMPLE IMAGE)

RANGE IMAGE
(LATEST IMAGE)

IMAGE DEFORMATION
SECTION ⌐2

DEFORMED
IMAGE

IMAGE COMPARISON
SECTION ⌐3

RANGE IMAGE
(LATEST IMAGE)

IMAGE COMPRESSION
SECTION ⌐9

MOTION RECOGNITION
SECTION ⌐4

COMPRESSED IMAGE

COMMUNICATION
SECTION ⌐10

FIG. 37